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Coastal Cloud Chemistry during EPCAPE Field Campaign Report

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ARM

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Acronyms and Abbreviations

AOS	Aerosol Observing System
ARM	Atmospheric Radiation Measurement
CCN	cloud condensation nuclei, cloud condensation nuclei particle counter
CPC	condensation particle counter
CVI	counterflow virtual impactor
EPCAPE	Eastern Pacific Cloud Aerosol Precipitation Experiment
HTDMA	humidified tandem differential mobility analyzer
SMPS	scanning mobility particle sizer

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1.0 Summary

1.1 Overview

For this campaign, Principal Investigator Markus Petters deployed a suite of instruments inside Lynn Russell's container that was sited at Mt. Soledad during the Eastern Pacific Cloud Aerosol Precipitation Experiment (EPCAPE) campaign. Funding for this activity was provided by National Science Foundation Award 2410536. The instrument rack (Figure 1) included a differential mobility analyzer, a condensation particle counter, a portable optical particle spectrometer, and a continuous flow diffusion cloud condensation nuclei counter (CCN). The instruments sampled from a counterflow virtual impactor (CVI) inlet and an isokinetic inlet. The measurements provided aerosol size distribution, size-resolved CCN activity, and denuded versus undenuded CCN activity of aerosols and cloud drop residuals. In addition to replicating some of the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) user facility measurements at the Scripps Pier at a location closer to cloud base, these measurements were designed to address these two science questions:

1. Does removing the gas-phase components by denuding effect drop activation in clean or polluted conditions at Mt. Soledad?
2. Does removing the gas-phase components by denuding effect the growth rate of cloud droplets?

Figure 1. Interior of the trailer. The denuded/undenuded CCN rack is to the right.

1.2 Data Quality

Measurements were collected between February and August 2023. A solenoid valve failed in the CCN instrument, which caused a data outage from 04/11/2023 to 04/18/2023. Between 05/09/2023 and 05/12/2023, silica gel blocked the inlet to the instrument, resulting in decreased counting efficiency in the scanning mobility particle sizer (SMPS) and CCN. Starting the week of 08/04/2023, the laser in the condensation particle counter (CPC) began to fail, resulting in a gradual decreased counting efficiency in the CPC. The resulting SMPS and CCN data are reported in the ARM Data Center but need to be interpreted with caution.

2.0 Results

2.1 Hygroscopicity Data

The campaign provided conventional size-resolved CCN data from the undenuded channel. The hygroscopicity parameter κ typically varied between 0.2 and 0.4 before, during, and after the cloud event for all supersaturations except s = 0.2%, which often showed much higher κ values. Figure 2 shows a comparison of the CCN-derived and humidified tandem differential mobility analyzer (HTDMA)-derived hygroscopicity parameter, κ, for 50-nm particles. Note that the HTDMA was located inside the Aerosol Observing System (AOS) container at the M1 site, which is several kilometers away from Mt. Soledad. Similarly to many previous measurements, the CCN-derived κ correlated with the HTDMA-derived κ generally but exceeded the HTDMA-derived κ by up to 50%.

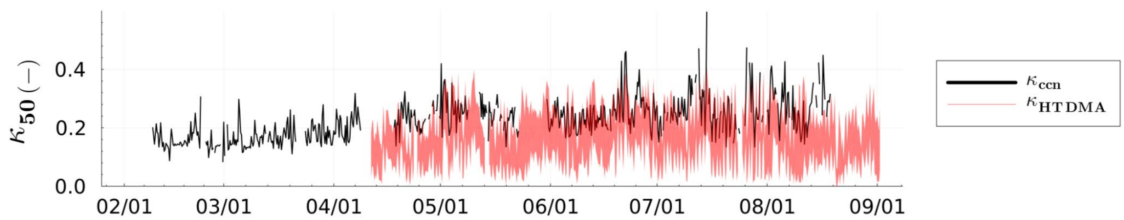

Figure 2. Comparison of the hygroscopicity parameter (κ) for 50-nm particles, derived from AOS HTDMA at M1 and CCNc at Mt. Soledad. The shading represents the κ of the less and more hygroscopic mode determined by the inversion. The x-axis shows month/date in 2023.

2.2 CVI Data

Results show that integrated aerosol number concentration behind the CVI correlated well with cloud droplet number concentration derived from a co-located fog droplet monitor. Although the majority of cloud droplet residuals re-activates inside the CCN, a small but consistent fraction of particles did not reactivate even at supersaturations much higher than the expected in-cloud supersaturation.

2.3 Denuded versus Undenuded CCN

The denuder efficiently removed alkanes, and weakly functionalized acids, aldehydes, and alcohols with fewer than 10 carbon atoms from the gas phase. Inclusion of the denuder perturbed the derived κ by up to 50%. The effect was intermittent, dependent on aerosol hydration, and much larger compared to typical changes in κ that occur due to chemical aging of organic aerosol in the atmosphere. The effect was weakest in early spring and strongest in late spring and summer. When present, the effect of denuding was often, but not always, to render the particles less CCN active.

3.0 Publications and References

3.1 Published Data Sets

Identical data sets are published as part of the University of California, San Diego digital collection and the ARM Data Archive.

Petters, Markus; Ravichandran, Elavarasi; Williams, Abigail S.; Han, Sanghee; Pelayo, Christian; Dedrick, Jeramy L.; Russell, Lynn M. 2023. Cloud Condensation Nuclei and Printed Optical Particle Spectrometer Measurements at Mt. Soledad during EPCAPE 2023-24. In Aerosol Microphysics and Chemical Measurements at Mt. Soledad and Scripps Pier during the Eastern Pacific Cloud Aerosol Precipitation Experiment (EPCAPE) from February 2023 to February 2024. UC San Diego Library Digital Collections. https://doi.org/10.6075/J0KH0NHG

ARM Data Archive: Cloud Condensation Nuclei and Printed Optical Particle Spectrometer Measurements at Mt. Soledad during EPCAPE 2023-24. https://doi.org/10.5439/2438498

3.2 Conference Presentations to Date

Ravichandran, E, S Han, A Williams, J Dedrick, C Pelayo, N Maneenoi, L Robinson, R Chang, M Wheeler, J Wentzell, J Liggio, L Russell, and M Petters. 2024. "Influence of Gas Phase Compounds on CCN activity observed during the Eastern Pacific Cloud Aerosol Precipitation Experiment." Presented at the American Association for Aerosol Research Annual Conference, Albuquerque, New Mexico.

Petters, M, E Ravichandran, S Han, A Williams, J Dedrick, C Pelayo, N Maneenoi, L Robinson, R Chang, M Wheeler, J Wentzell, J Liggio, and L Russell. 2024. "Influence of Gas Phase Compounds on CCN activity observed during the Eastern Pacific Cloud Aerosol Precipitation Experiment." Presented at the American Geophysical Union Annual Conference, San Francisco, California.

Ravichandran, E, S Han, A Williams, J Dedrick, C Pelayo, N Maneenoi, L Robinson, R Chang, M Wheeler, J Wentzell, J Liggio, L Russell, and M Petters. 2023. "Size-Resolved CCN Activity of Cloud Droplet Residuals during the Eastern Pacific Cloud Aerosol Precipitation Experiment." Presented at the American Geophysical Union Annual Conference, San Francisco, California.

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